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350/1.6

INTERFERENCE FILTERS

Transmission Type



BAUSCH & LOMB INCORPORATED
ROCHESTER 2, NEW YORK

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Transmission Type

Transmission type interference filters possess narrow pass bands and consequently transmit light of high spectral purity. They are made for use throughout the wavelength region from 330m μ to 1200m μ . In the tabulation to follow, filters for certain definite wavelengths with specific optical characteristics are offered as stock items.

The filter proper consists of two highly reflecting but partially transmitting films of silver separated by a spacer film of non-absorbing material. This combination is deposited on a glass plate by high vacuum methods and a cover plate is then cemented on for protection. The separation of the silver films governs the wavelength position of the pass band and hence the color of the light which the filter will transmit. This is the result of an optical interference effect which produces a high transmission of light when the optical separation of the silver films is effectively a half wavelength or a multiple of a half wavelength. Light which is not transmitted is for the most part reflected. The construction of the filter and the origin of the interference in the multiple reflections between the silver films is shown diagrammatically in Fig. 1. At a wavelength for which the multi-reflected beams emerge in phase, as shown, the filter has a high transmittance. Light of other wavelengths is not transmitted, rather it is reflected.

An interference filter is characterized optically by the wavelength position λ of the peak of the pass band, by

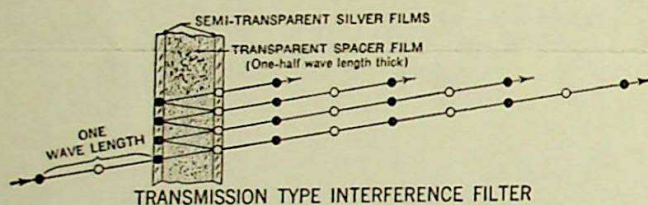


FIG. 1

the transmittance T at the peak of the pass band and by the half width HW . The half width is convenient for expressing filter selectivity. It is defined as the spectral width of the pass band in millimicrons at the level where the transmittance is one half the peak transmittance. The characteristic features of a pass band are illustrated in Fig. 2.

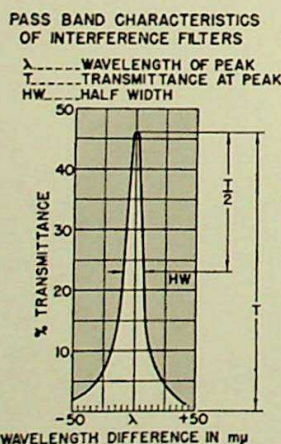


FIG. 2

A filter in which the optical spacing of the silver films is one-half wavelength at the pass band for which it was designed, as in Fig. 1, is called a first order filter, one in which the spacing is two half wavelengths is called a second order filter, and so on. Both first and second order filters are offered.

The selectivity as expressed by the half width depends on the order of interference of the filter, and also on its

transmittance. Transmittances being equal, a first order filter inherently has a wider pass band than a second order filter. Order of interference being equal the higher the peak transmittance the wider the pass band. Bausch & Lomb Interference Filters have been designed to provide optimum transmittance with due regard to selectivity.

The application to which the filter is to be put may determine the choice of order of interference. The first order filter with its greater half width passes more energy and finds use, for example, in colorimetry and photomicrography.

When a high order of selectivity is desired for the isolation of a chosen spectral line, or of a narrow spectral region from a white light source, the second order filter is recommended.

Bausch & Lomb standard first order filters are manufactured with a nominal peak transmittance of 45%, second order filters with a nominal peak transmittance of 35%. The half width is somewhat dependent on wavelength, but throughout most of the range offered, first order filters have a half width less than 20m μ and second order filters a half width less than 10m μ .

Spectrophotometric curves of typical first order filters are plotted in Figs. 3a, 3b, and 3c, and of typical second order filters in Figs. 4a, 4b, and 4c.

In the use of any interference filter, the presence of pass bands other than the nominal must be considered. Pass bands occur whenever the optical spacing of the silver films is any whole multiple of a half wavelength, subject to limitations arising from absorption or other properties of the various materials used in the filter. As an example, a nominal second order filter for 710m μ will have a third order pass band in the blue near 475m μ , and a first order pass band in the infra-red near 1420m μ . Whereas the third order pass band in the blue is very prominent, compare Fig. 4c, the first order peak in the infra-red has a low transmittance and may often be disregarded. In first order filters there are no pass bands on the long wavelength side of the nominal pass band, the nearest neighbor being the second order pass band at approximately one-half the wavelength of the nominal.

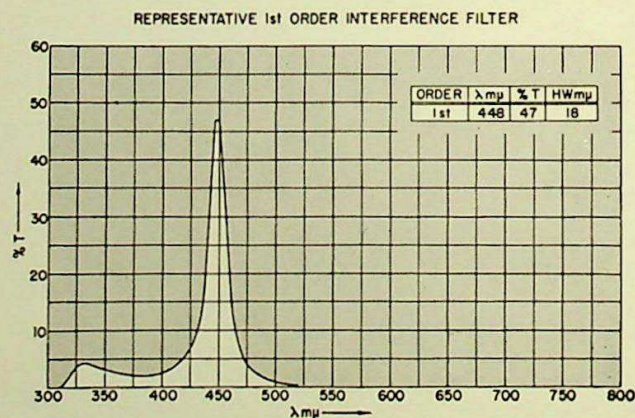


FIG. 3a

REPRESENTATIVE 1st ORDER INTERFERENCE FILTER

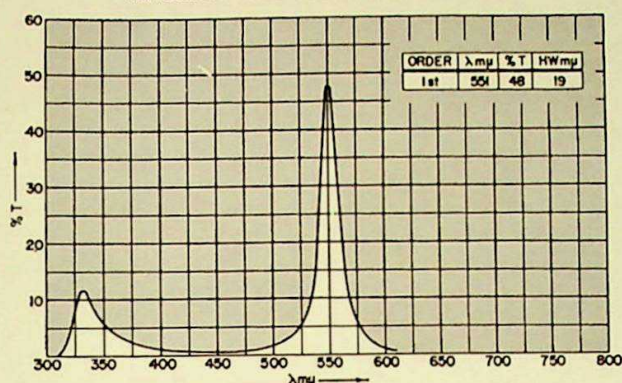


FIG. 3b

REPRESENTATIVE 1st ORDER INTERFERENCE FILTER

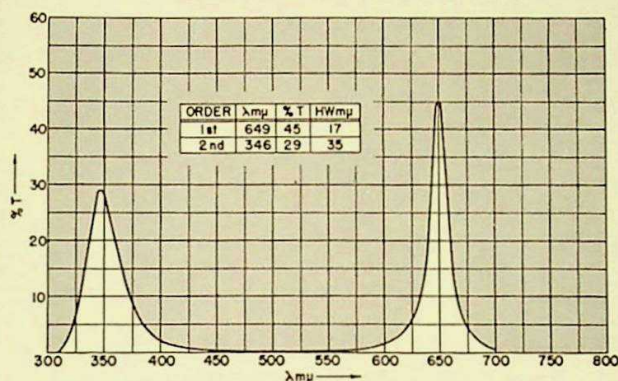


FIG. 3c

REPRESENTATIVE 2nd ORDER INTERFERENCE FILTER

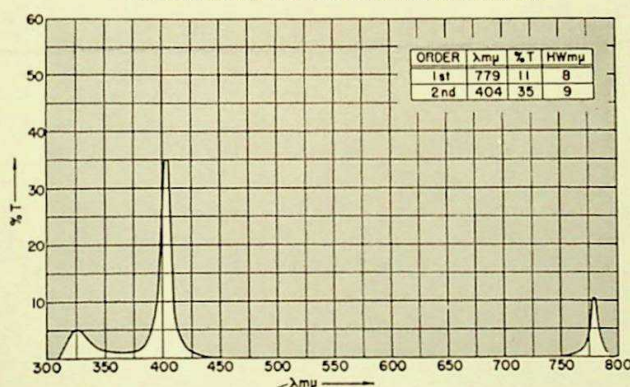


FIG. 4a

REPRESENTATIVE 2nd ORDER INTERFERENCE FILTER

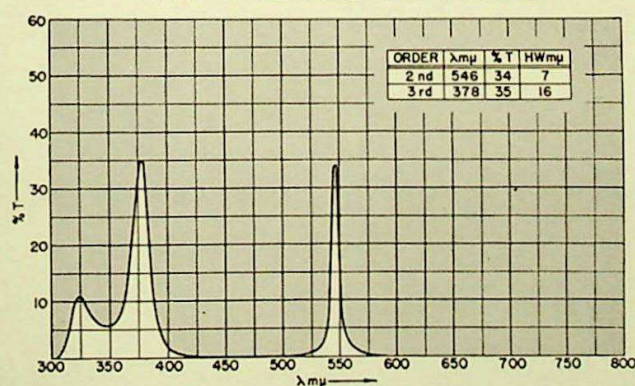


FIG. 4b

REPRESENTATIVE 2nd ORDER INTERFERENCE FILTER

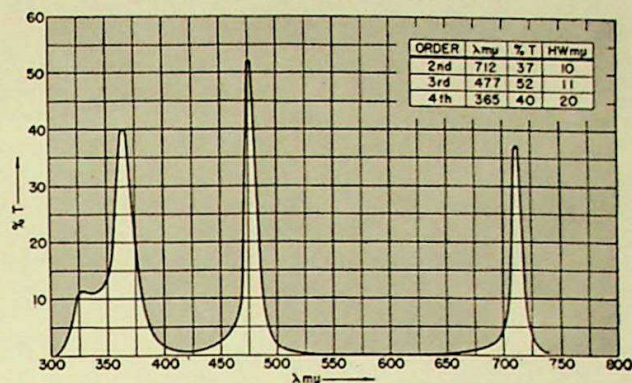


FIG. 4c

To permit the use of the filter at these extra pass bands, and thereby extend its application, the cover plates are clear glass. However, in those cases where the extra pass bands are objectionable, they can be eliminated by means of separate glass or other types of auxiliary filters. In filter manufacture only the nominal pass band is held to specifications. All of the filters have a slight background transmittance of the order of one half of one percent or less and may also show a small transmittance in the region around 330 $m\mu$ due to the optical characteristics of the silver films in this region. Occasionally a spectrophotometric problem will require careful elimination of the background, through the use of auxiliary filters.

An inherent property of the interference filter is the decrease in wavelength position of a pass band when the filter is tilted. This becomes apparent as a change in color for angles of incidence of more than 15° or 20°. Furthermore, the pass band gradually develops into a doublet of increasing separation as the angle of incidence on the filter is increased. The shorter wavelength component has the property of transmitting light vibrating only at right angles to the plane of incidence, the s-component. The longer wavelength component transmits light vibrating only in the plane of incidence, the p-component. This behavior is illustrated by the curves of Fig. 5 which shows the shift in wavelength and the extent of the doubling in two first order filters and two second order filters as a function of angle of incidence. All filter specifications in the catalog listing are for normally incident light.

It is to be emphasized that any spectrophotometer used to measure the transmittance and half width of interference filters must have adequate resolving power. For practical measurement the band pass of the instrument in wavelength units must not exceed one-fifth the half width of the filter under measurement. For example, the spectral transmittance and half width of second order filters of 10 $m\mu$ half width cannot be measured accurately with a spectrophotometer having a band pass of much more than 2 $m\mu$. When wider pass bands are used in the instrument, the measured transmittance of the filter decreases from the true value and the measured half width increases. Thus a normally performing interference filter may appear to have sub-standard characteristics if the spectrophotometer used in measuring it has inadequate resolving power.

The property of very high reflectance at wavelengths other than the region of the pass band should be considered in the measurement and in the use of an interference filter. If there is any disturbance from this reflected light, it can generally be avoided by slightly tilting the filter.

Bausch & Lomb Transmission Type Interference Filters have good stability and permanence when used under normal conditions and when placed at a reasonable distance from the light source so that excess heating of the filter is avoided. Operation of the filter above a temperature of 80°C is not recommended.

Interference filters offer a convenient and inexpensive means of isolating specific spectral bands. Their use in the fields of colorimetry, color densitometry, photomicrography and flame photometry is already established. Being a relatively new development, many further applications are prospective, particularly when cost and compactness are factors.

WAVELENGTH SHIFT AND DOUBLING WITH ANGLE OF INCIDENCE

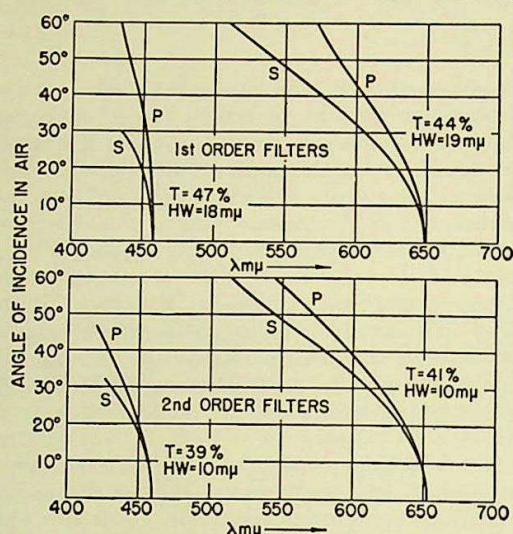


FIG. 5

It will be appreciated that the most exacting control of the high vacuum process for the deposition of films is exercised in order to insure accuracy, uniformity and stability. No dyes or other coloring media are employed, assuring permanence of characteristics. Bausch & Lomb has pioneered in the field of filming, having made the first commercially available anti-reflection coating, while in the deposition of metal films the Company is able to draw on years of experience. B&L offers these Interference Filters with complete confidence in their performance.

Specifications, Prices and Ordering Information

PHOTOMICROGRAPHIC SERIES—First Order Interference			
Catalog Number	Wavelength	Peak Transmittance	Half Width Maximum
42-47-55	450mμ	45%	20mμ
42-47-56	500mμ	45%	20mμ
42-47-57	550mμ	45%	20mμ
42-47-58	600mμ	45%	20mμ
42-47-59	650mμ	45%	20mμ

Tolerances—Wavelength: +15mμ, -15mμ

Minimum Transmittance: 35%.

Size—2" x 2" x 3/16".

Identification—Engraved with Nominal Wavelength Value.

Price—\$18.00 each.

Prices are subject to change without notice. Orders are subject to acceptance at Rochester, N. Y., U. S. A., at prices prevailing at time of shipment. Orders for standard items may be cancelled if not wanted because of price advance. Excise taxes or other governmental charges will be added wherever applicable. Shipments to points outside Continental United States of America and to its territories, dependencies and possessions, except Hawaii and Alaska, are not subject to excise taxes. Delivery dates are estimated and cannot be guaranteed.

The following filters are typical of hundreds made by Bausch & Lomb. If one of the wavelength or size you require (anywhere in the 330mμ-1200mμ range) is not listed, write to the Company, Rochester 2, New York.

STANDARD SERIES—Second Order Interference			
Catalog Number	Wavelength	Peak Transmittance	Half Width
33-78 plus first 2 digits of peak wave-length	340mμ	30%	20mμ
	365mμ	30%	25mμ
	380mμ	35%	16mμ
	390mμ	35%	14mμ
	400mμ	35%	12mμ
	410mμ	35%	10mμ
	420, 430, 440, 450mμ	35%	9mμ
	460mμ through in 10mμ steps	35%	8mμ
	660, 670, 680, 690, 700mμ	35%	9mμ
	710, 720, 730, 740, 750, 760, 770, 780, 790, 800mμ	35%	10mμ

Tolerances—Wavelength: +5mμ, -2mμ.

Minimum Transmittance: 32%, except 25% for 340 and 365mμ.

Half width: Not to exceed nominal by more than 2mμ, except 5mμ for 340 and 365mμ.

Size—2" x 2" x 3/16".

Identification—Engraved with Nominal Wavelength Value.

Price—\$22.00 each, except { 33-78-34 }
{ 33-78-36 } which are \$25.00 each.
{ 33-78-80 }

SELECTED LINE SERIES—Second Order Interference			
33-79-40	405mμ (Hg)	35%	12mμ
33-79-43	436mμ (Hg)	35%	9mμ
33-79-48	486mμ (H)	35%	8mμ
33-79-51	517mμ (Mg)	35%	8mμ
33-79-54	546mμ (Hg)	35%	8mμ
33-79-57	578mμ (Hg)	35%	8mμ
33-79-58	589mμ (Na)	35%	8mμ
33-79-64	644mμ (Cd)	35%	8mμ
33-79-65	656mμ (H)	35%	9mμ
33-79-76	768mμ (K)	35%	10mμ

Tolerances—Wavelength: +2mμ, -2mμ.

Minimum Transmittance: 32%.

Half width: Not to exceed nominal by more than 2mμ.

Size—2" x 2" x 3/16".

Identification—Engraved with Nominal Wavelength Value and marked with Actual Value.

Price—\$32.00 each.

Filters are individually packed. However, where desired, containers for groups of filters are available as follows:

Catalog No. 31-34-78, to hold 6 filters, Price \$4.00.

Catalog No. 33-79-05, to hold 15 filters, Price \$8.60.

Measured spectrophotometric transmittance curves of individual filters may be obtained at \$15.00 net, per filter. These curves cover the spectral region from 1% transmittance on the low wavelength side of the peak to 1% transmittance on the high side of the peak. Specify catalog No. 33-78-01 for this service in addition to full ordering data on each filter desired. Give catalog number or series and peak wavelength.

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